

HYDROCHEMISTRY OF LAVA TUBE SPRING AND THE RIO GRANDE, TAOS COUNTY, NEW MEXICO

BY

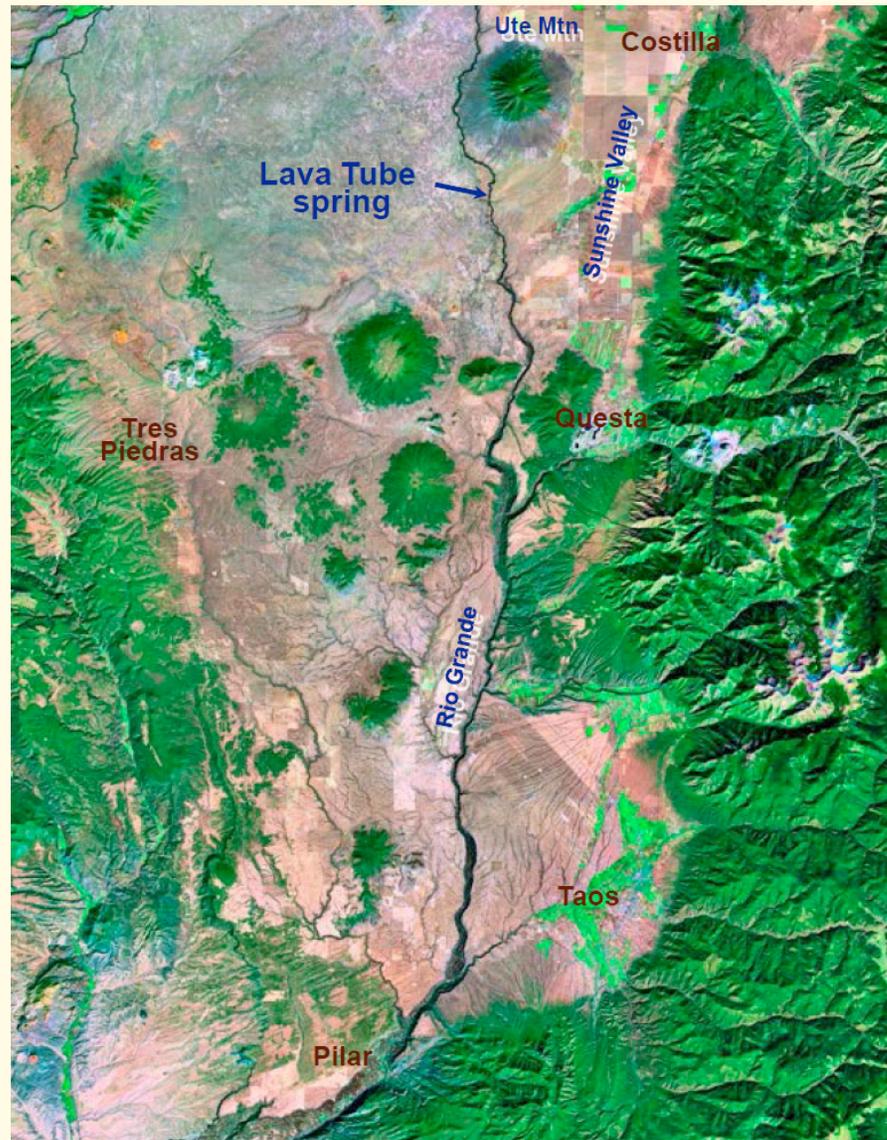
**¹PATRICK LONGMIRE, ¹MICHAEL DALE, ¹KIM GRANZOW,
¹DONALD CARLSON, ¹BENJAMIN WEAR, ¹JERZY KULIS,
²GEORGE PERKINS, AND ²MICHAEL REARICK**

**¹NEW MEXICO ENVIRONMENT DEPARTMENT
²LOS ALAMOS NATIONAL LABORATORY**

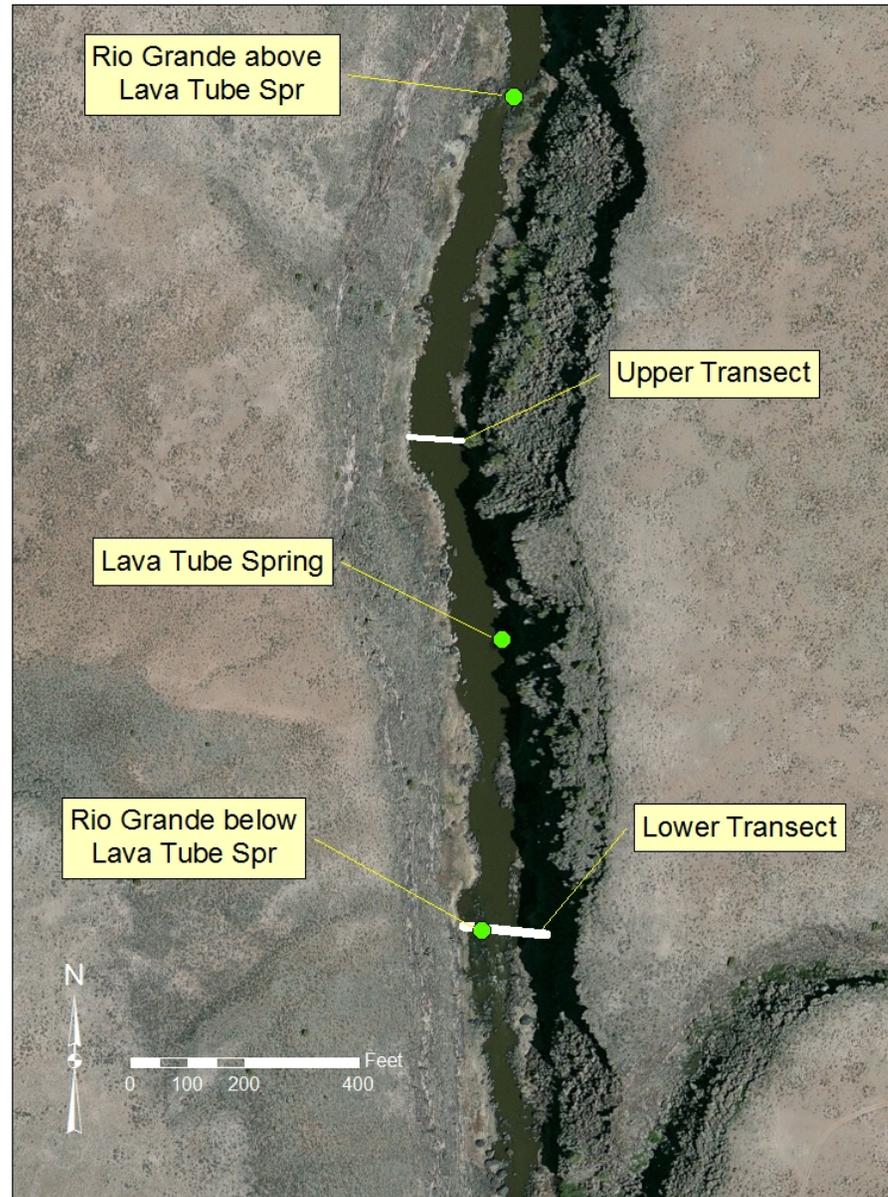
HYDROCHEMISTRY OF LAVA TUBE SPRING AND THE RIO GRANDE, TAOS COUNTY, NEW MEXICO

- I. Introduction**
- II. Flow Rates and Mixing**
- III. Aqueous Chemistry**
- IV. Batch Equilibrium Modeling**
- V. Summary**

LOCATION MAP OF LAVA TUBE SPRING AND SURROUNDING AREA, TAOS COUNTY



MAP SHOWING LAVA TUBE SPRING, RIO GRANDE, AND SURFACE WATER TRANSECTS, TAOS COUNTY



**PHOTOGRAPH OF LAVA TUBE SPRING DICHARGING INTO THE
RIO GRANDE (Source: P. Bauer and P. Johnson, 2010)**



**Depth: 12 ft, Width: 15 ft
Discharge: 5835 gal/min in fall 2009
12,565 gal/min in July 2012 (NMED)**

Upwelling Gravel

Bauer, P. W. and Johnson, P. S., 2010, A rare, large artesian subaqueous spring in the upper Rio Grande: New Mexico Geology, Vol. 32, no. 1, 26-29 pp.

**SURFACE WATER FLOW IN THE RIO GRANDE ABOVE AND BELOW
LAVA TUBE SPRING (LTS), TAOS COUNTY, NEW MEXICO**

Parameter	Above LTS	Below LTS
Total Width (ft)	72.6	84.7
Average Depth (ft)	2.81	1.58
Total Area (ft²)	175	98.9
Average Velocity (ft/sec)	0.38	0.87
Total Discharge (ft³/sec)	67	95
No. Measurements	42	56

FIELD PARAMETERS FOR LAVA TUBE SPRING (LTS) AND RIO GRANDE SURFACE WATER

Parameter	Above LTS	Lava Tube Spring	Below LTS
pH	7.56	7.58	7.49
Temperature (°C)	22.5	16.7	20.5
Specific Conductance (µS/cm)	395	191	337
ORP (mV)	+96.7	+103	+100
Eh (mV)	+341	+347	+344
Dissolved Oxygen (mg/L)	9.36	8.84	9.57

Note: Three measurements of each parameter were taken at each Rio Grande location. One measurement of each parameter was taken at LTS.

ANALYTICAL METHODS

Analyte Suite

Analytical Methods

Anions

Ion Chromatography

Metals-Trace Elements

**High Resolution-Mass Spectrometry,
Inductively Coupled-Mass Spectrometry**

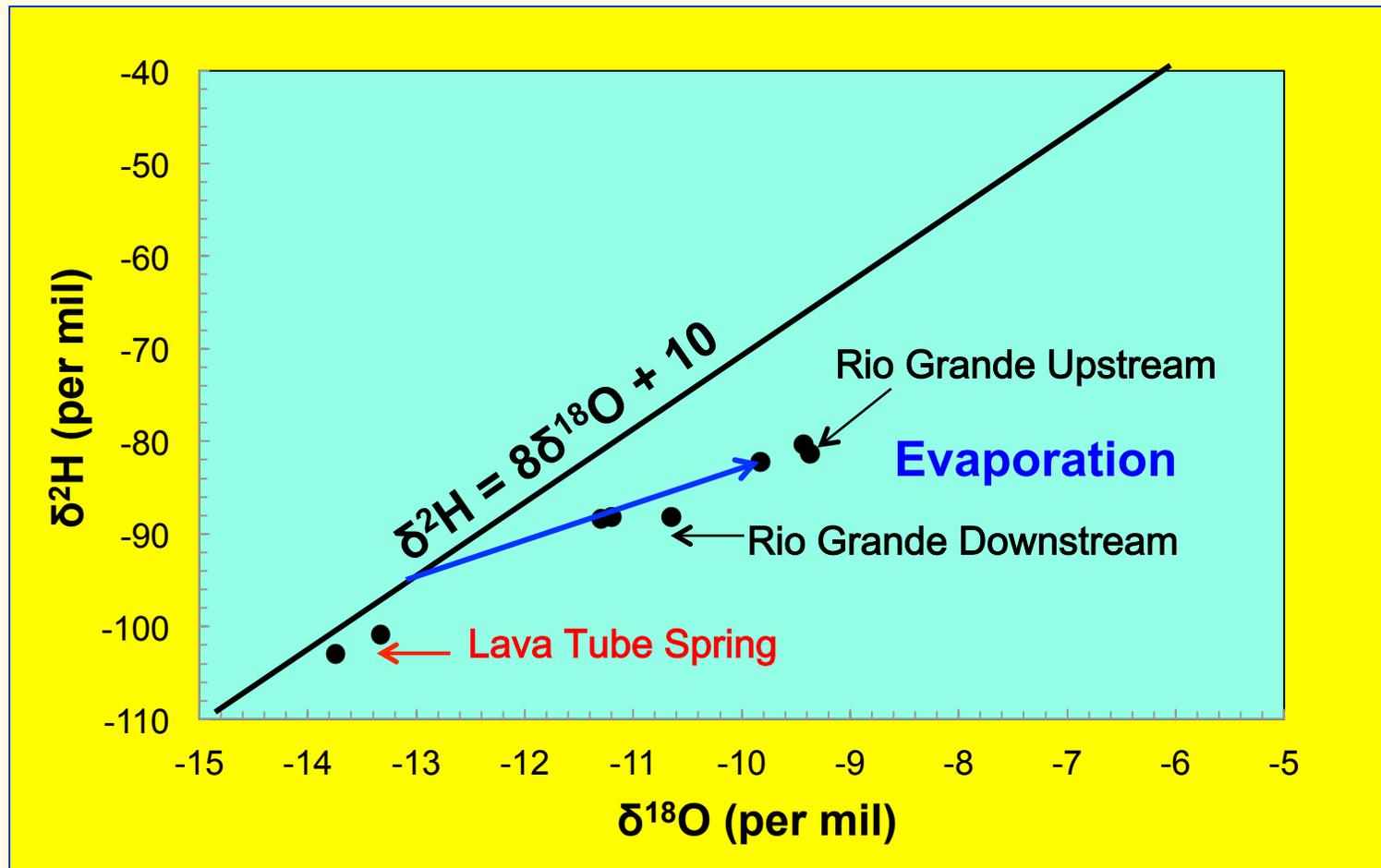
Stable Isotopes

Isotope Ratio Mass Spectrometry

Tritium

Electrolytic Enrichment

$\delta^{18}\text{O}$ VERSUS $\delta^2\text{H}$ AT LAVA TUBE SPRING AND THE RIO GRANDE



RESULTS OF MIXING CALCULATIONS USING TRACER CONCENTRATIONS AND PHYSICAL PARAMETERS FOR LAVA TUBE SPRING AND THE RIO GRANDE

Parameter	Above	Lava Tube Spring	Below	Mixing
Cl (mg/L)	11	4	9	0.29
³ H (TU)	4.14	0.12	2.88	0.31
δ ² H (‰)	-81.82	-102.91	-88.28	0.31
U (µg/L)	1.53	2.23	1.79	0.37
δ ¹⁸ O (‰)	-9.54	-13.56	-11.05	0.38
SO ₄ (mg/L)	38	14	29	0.38
Discharge (ft ³ /sec)	67	28	95	0.29
Temp. (°C)	22.5	16.7	20.5	0.34

Note: Three filtered-nonfiltered samples were collected at each Rio Grande location. One sample was collected at LTS. TU = tritium unit (3.222 pCi/L). Input from small discharging springs located above Lava Tube spring is assumed to be negligible.

Mixing Eq. $C = A(X) + B(1 - X)$

where A = parameter A (upstream), B = parameter B (lava Tube spring), C = parameter C (downstream), and X = mixing fraction.

AVERAGE SOLUTE CONCENTRATIONS FOR LAVA TUBE SPRING (LTS) AND THE RIO GRANDE

Parameter (mg/L)	Above LTS	Lava Tube Spring	Below LTS
Ca	32.8	20.9	28.7
Mg	7.52	6.93	7.30
Na	40.1	13.8	31.4
K	7.0	2.7	5.55
SO ₄	38	14	29
HCO ₃	175	116	145
Cl	11	4	9
SiO ₂	26.1	38.8	29.6

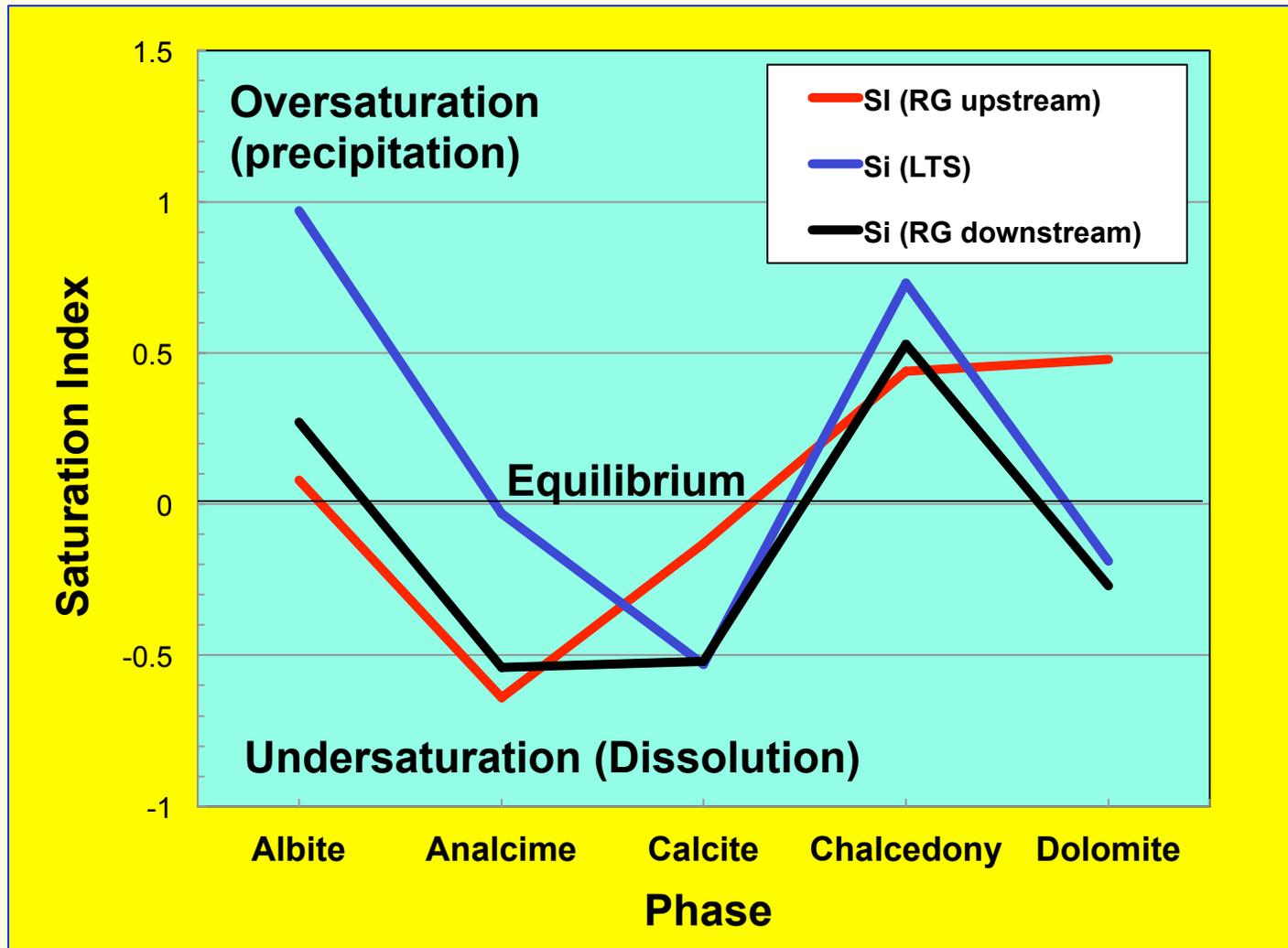
Note: Three filtered samples were collected at each Rio Grande location. One filtered sample was collected at LTS.

AVERAGE SOLUTE CONCENTRATIONS FOR LAVA TUBE SPRING (LTS) AND THE RIO GRANDE

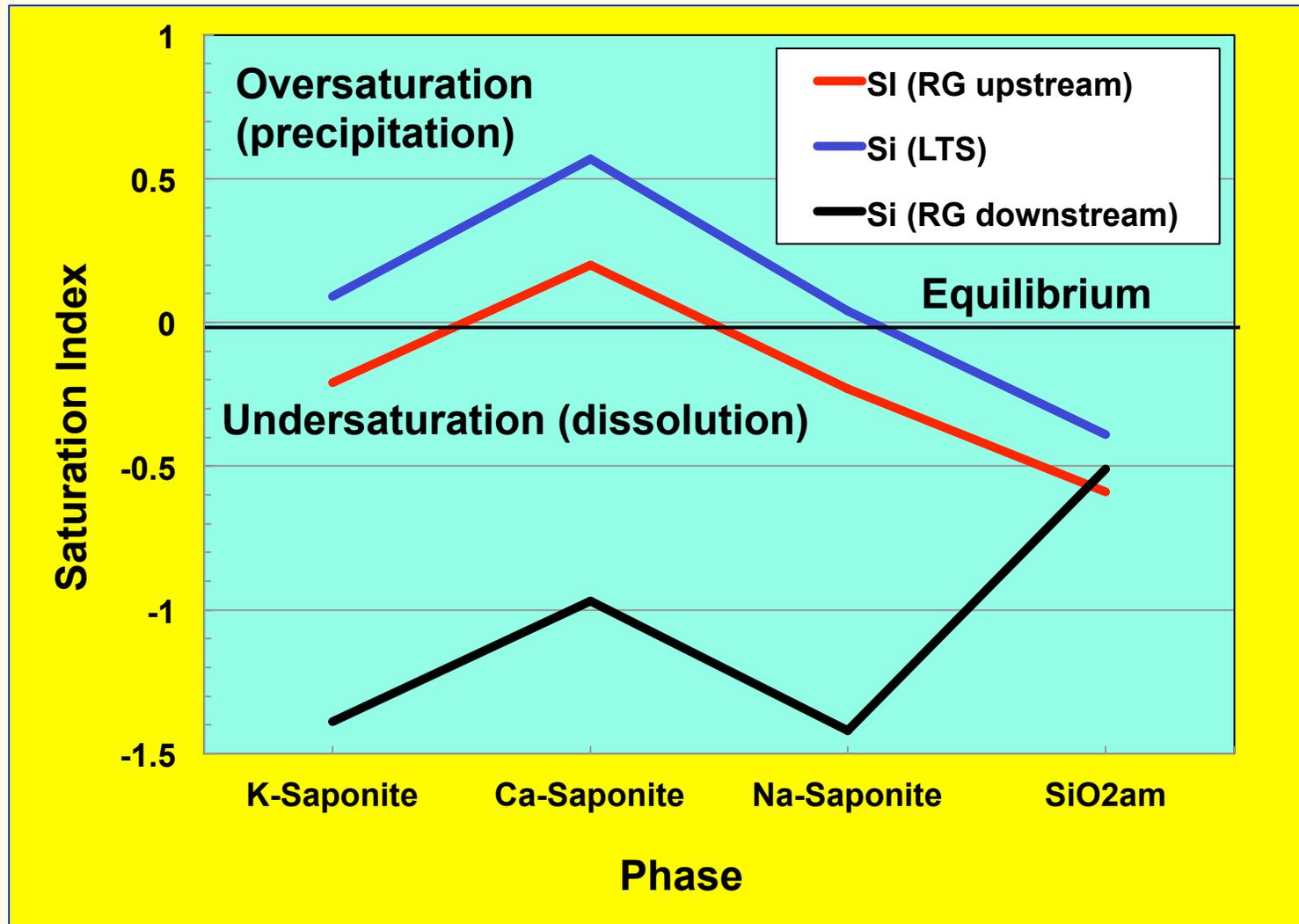
Parameter ($\mu\text{g/L}$)	Above LTS	Lava Tube Spring	Below LTS
Al	1.44	0.39	1.26
As	4.57	2.52	3.53
B	88.1	33.2	74.0
Cr	0.085	2.03	0.714
Fe	0.01 U	0.01 U	0.01 U
Mn	9.39	0.26	6.37
Sr	243	167	228
U	1.53	2.23	1.79

Note: Three filtered samples were collected at each Rio Grande location. One filtered sample was collected at LTS. U means nondetected analyte.

RESULTS OF SATURATION INDEX CALCULATIONS USING PHREEQC



RESULTS OF SATURATION INDEX CALCULATIONS USING PHREEQC



SUMMARY

Lava Tube spring is the largest single active spring in New Mexico, with calculated discharge rates 5835 gal/min in fall 2009 and 12,565 gal/min in July 2012.

Groundwater discharging from Lava Tube spring mixes with the Rio Grande surface water and constitutes between 29 and 38 percent of chemical tracers.

Rio Grande surface water and groundwater discharging from Lava Tube spring are characterized by a Na-Ca-HCO₃ composition.

Recharge water for Lava Tube spring occurs at a higher elevation than the Rio Grande (showing some evaporation) based on lighter $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values.

Lava Tube spring approaches equilibrium with respect to Na- and K-saponite and analcime most likely produced from hydrolysis reactions with Servilleta basaltic glass.

Acknowledgment: "This material is based upon work supported by the Department of Energy Office of Environmental Management under Award Number *DE-EM0002420*."

Disclaimer: "This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."